Europa Orbiter Mission Trajectory Design

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The Europa Orbiter mission (the first of three missions planned for the Outer Planets/Solar Probe Program) will place a spacecraft in orbit about Europa in an attempt to determine whether or not a subsurface ocean exists on Europa. The Galileo mission has provided evidence that such an ocean existed in the past. The Europa Orbiter spacecraft will perform mapping and gravity/altimetry studies for 30 days from a tight 100-200 km altitude orbit about Europa in order to characterize the distribution of any subsurface water and identify sites for future lander missions.

In the reference mission, the spacecraft will launch in November 2003 aboard an STS and inject into a Type II direct trajectory to Jupiter using an IUS/Star48V upper stage. Jupiter arrival varies from July 2006 to August 2007, depending on the launch date within a 21-day period. The C_3 for such a variable arrival day strategy is fixed at 80 km^2/s^2. The interplanetary trajectory (Fig. 1) requires a broken plane maneuver which varies from about 270 m/s at the start of the launch period to nearly zero at the end of the launch period.

A close flyby of Ganymede reduces the ΔV required for capture at Jupiter. The orbit insertion maneuver takes place at the relatively high perijove range of 12.5 Jupiter radii. This scenario is favored over an insertion at a much lower perijove range following an Io flyby, since it avoids the high radiation environment and any debris problems associated with ring plane crossing. Strategies for further reducing the insertion ΔV, such as incorporating a second satellite flyby following perijove, are described and evaluated.

Following an initial 200-day orbit and small perijove raise maneuver, a nearly ballistic Galileo-like satellite tour reduces the orbital period to about 10 days. Next in the "endgame" phase, a series of nearly resonant Europa encounters and apojove maneuvers further reduce the period about Jupiter to be nearly commensurate with that of Europa. The high radiation environment limits the amount of "resonance hopping" which can be performed prior to orbit insertion about Europa. The ΔV and radiation dosage from a scenario with capture utilizing third body effects from Jupiter are contrasted with direct insertion after only a few Europa flybys. The requirements for orbit inclination and node for the Europa orbital phase place additional constraints on trajectories and increase the ΔV cost. All trajectories are optimized and integrated using the CATO (Computer Algorithm for Trajectory Optimization) program. Strategies for solving convergence difficulties in the endgame phase are described.

A ΔV capability of about 2.5 km/s is allocated for the entire mission. This includes about 1.1 km/s for the combination of the broken plane, orbit insertion and perijove raise maneuvers, about 1.1 km/s for the endgame and Europa insertion maneuvers, and about 0.3 km/s for statistical ΔV and reserves. About 70% of the 950 kg spacecraft mass is associated with the propulsion system and propellant. Radiation shielding accounts for about 31 kg and allows for a 30 day orbital mission about Europa provided the total radiation dose is kept to <2 Mrad (behind 100 mils Al). The orbital phase is further constrained to occur while the spacecraft is within 5 AU from the Earth.

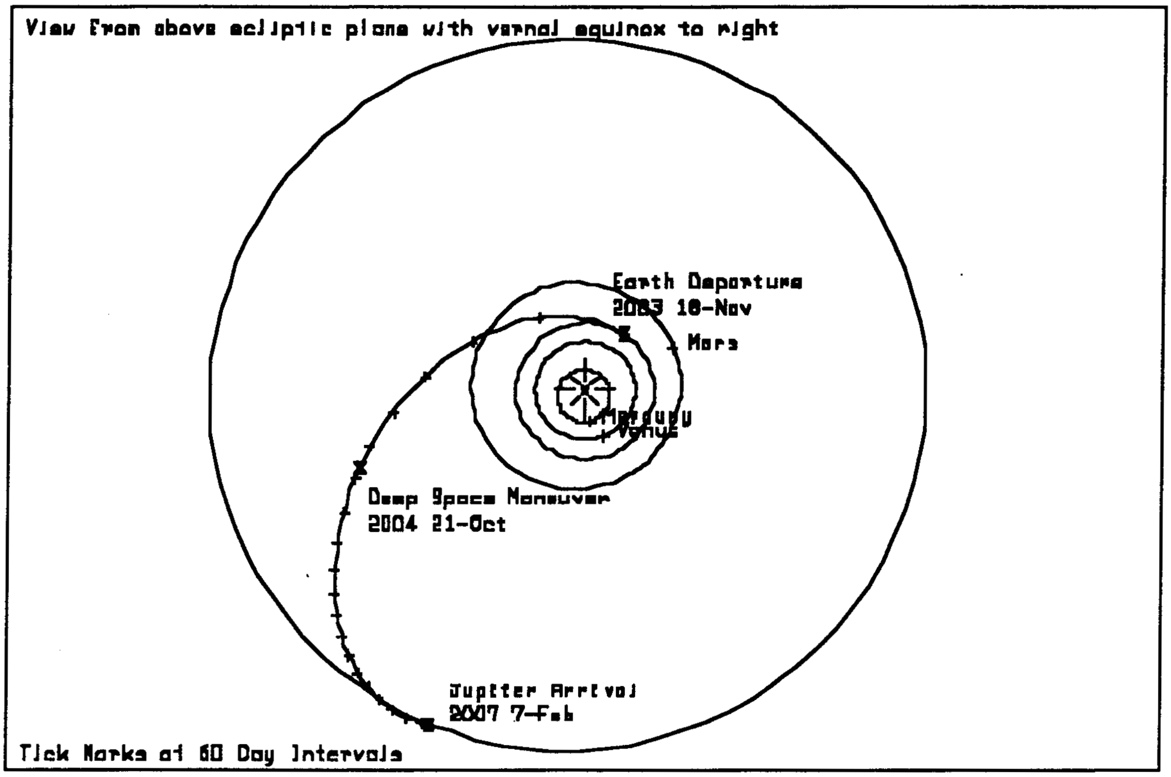

Fig. 1 Europa Orbiter Interplanetary Trajectory